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# Augmentation of the *In Vivo* Elastic Properties Measurement System to Include Bulk Properties

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## LONG-TERM GOALS

The goal of this project is to develop and demonstrate a system for non-invasive *in vivo* measurement of the complex elastic moduli (stiffnesses and loss factors) of cetacean head tissues. This system is ultimately intended to provide a portable diagnostic capability for use in stranded animal assessments.

## OBJECTIVES

Under a separate award, the investigators have been developing an ultrasound-based system for non-invasive *in vivo* determination of the complex shear elastic moduli (stiffness and loss) of cetacean head soft tissues. The objective of the present work is to augment the capabilities of the system (referred to as "CFE", for Convergent Field Elastography), to include determine bulk tissue speed and attenuation. Such data would provide previously unavailable *in vivo* information useful for applications such as cetacean sound exposure models and blubber thickness assessments, which have employed *ex vivo* data. Particularly critical in the bulk properties assessment is the attenuation as a function of frequency, and the extent to which it changes post mortem.

## APPROACH

The bulk properties measurement methods are intended to run concurrently with the existing shear measurement system. Bulk speed and attenuation in the 1-3 MHz range will be estimated using transmission and scattering data in the CFE system's primary operating band. Estimation of lower frequency (1-100kHz) properties will be based on the observation of sound generated at the modulation rate of the CFE system force generation transducer. Methods in both frequency ranges will make use of reference measurements made on tissue phantoms whose properties were independently determined, with refinement through the use of an analytical layered tissue model from which properties may be found through inversion.

Bulk properties estimation procedures will be tested on tissue phantoms with known properties, first with a homogeneous material, and then with a layered material. If successful, the configuration and procedures will be incorporated into the CFE system for animal testing.

## WORK COMPLETED

Initial work was focused on estimation of bulk soft tissue properties in the 1-3 MHz range.

## RESULTS

Calculations began with raw ultrasonic data acquired during live animal testing conducted under a separate effort. This data set was processed to yield estimates of bulk attenuation in extracranial soft tissues of a *Delphinapterus leucas* and two *Tursiops truncatus*. The results were at the low end of the range of reported values for in vitro mammalian fatty and connective tissues.

## IMPACT/APPLICATIONS

There is considerable interest in the development of structural acoustic models for the cetacean head for two main reasons: 1) to better understand biomechanics of sound reception and production in cetaceans, and 2) to understand and hopefully mitigate any harmful effects of man-made sound on their health and behavior. The development and validity of these models is severely limited by an almost complete lack of knowledge of the mechanical properties of the constituent living tissue. There is thus considerable interest in being able to measure these properties *in vivo*.

## RELATED PROJECTS

We applied for and received a NOAA permit to perform ultrasonic system testing on stranded animals.